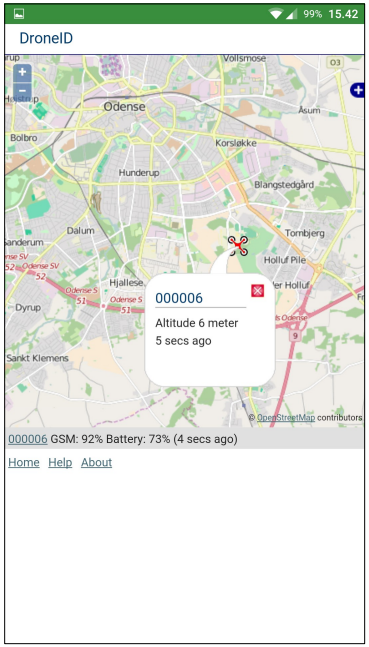
First Steps Toward UAS Traffic Management in Denmark



Nordic UAS Event 2016, Odense, Denmark

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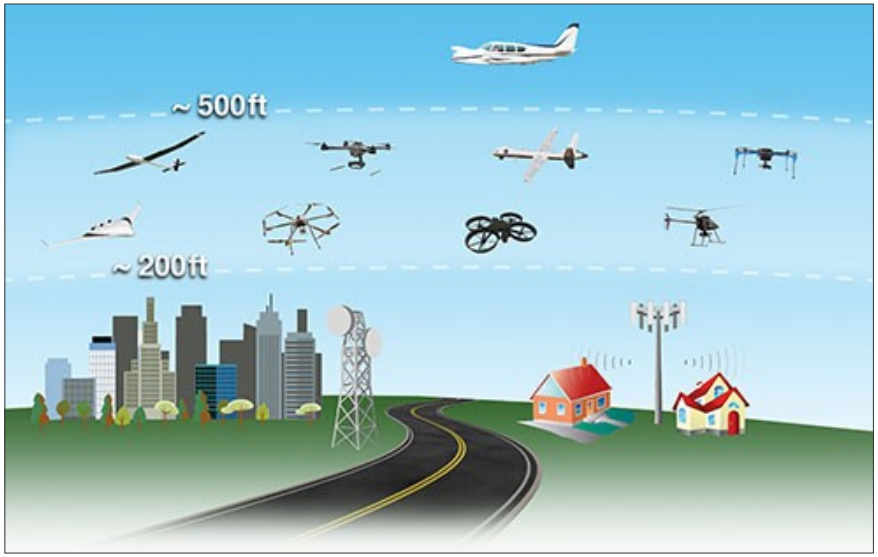
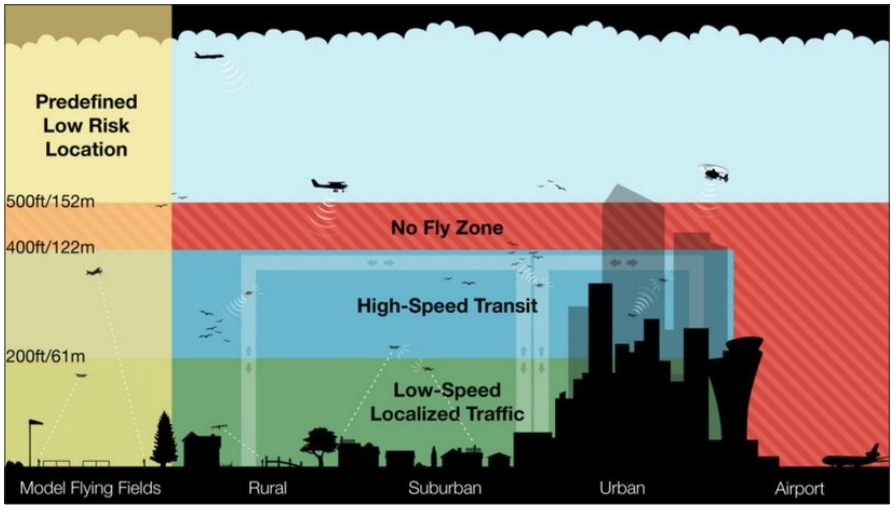
Program

1. UAS Traffic Management
2. The Danish DroneID project
3. Experiment fall 2015
4. Learned lessons
5. Work ahead

UAS Traffic Management (UTM)



"NASA's concept for a possible UTM system would safely manage diverse UAS operations in the airspace above buildings and below crewed aircraft operations in suburban and urban areas."



Amazon Prime Air concept

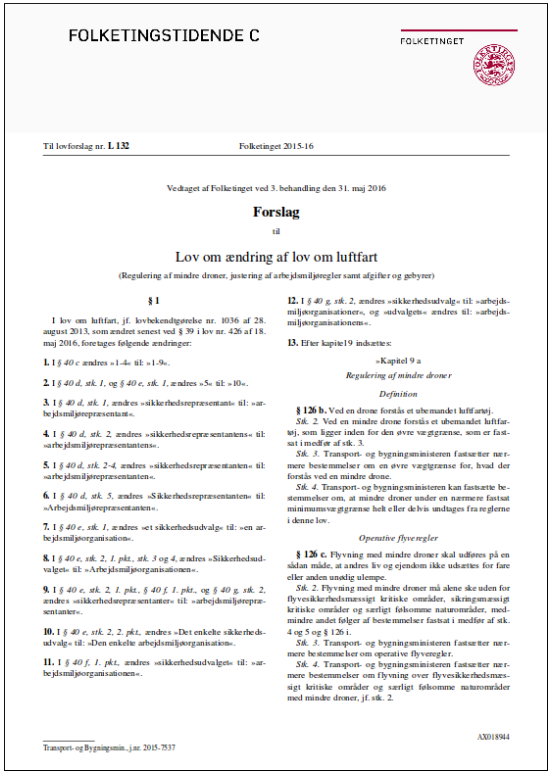
The Danish DroneID project

A **collaboration** between the **Danish Transport and Construction Agency** and the University of Southern Denmark launched in the **Summer 2015**.

The task is to **analyze the feasibility of deploying a drone identification and activity monitoring system** in Denmark as well as internationally. The aim is to provide the authorities with an overview over current and historical activity.

The project explores **two different architectures** in which the transmission is either a local **radio beacon signal** relayed to the UTM by the pilot or an observer, or it is transmitted directly from the drone to the UTM via **GSM**.

To the extent possible all results of the project including schematics, source code etc. are **released as permissive free open source**.



FOLKETINGSTIDENDE C

FOLKETINGET

Til lovforslag nr. **L 132** Folketinget 2015-16

Vedtaget af Folketinget ved 3. behandling den 31. maj 2016

Forslag

til

Lov om ændring af lov om luftfart

(Regulering af mindre droner, justering af arbejdsmiljøregler samt afgifter og gebyrer)

§ 1

I lov om luftfart, jf. lovbekendtgørelse nr. 1036 af 28. august 2013, som ændret senest ved § 39 i lov nr. 426 af 18. maj 2016, foretages følgende ændringer:

1. I *§ 40 c* ændres »1-4« til: »1-9«.

2. I *§ 40 d, stk. 1,* og *§ 40 e, stk. 1,* ændres »5« til: »10«.

3. I *§ 40 d, stk. 1,* ændres »sikkerhedsrepræsentant« til: »arbejdsmiljørepræsentant«.

4. I *§ 40 d, stk. 2,* ændres »sikkerhedsrepræsentantens« til: »arbejdsmiljørepræsentantens«.

5. I *§ 40 d, stk. 2-4,* ændres »sikkerhedsrepræsentanten« til: »arbejdsmiljørepræsentanten«.

6. I *§ 40 d, stk. 5,* ændres »Sikkerhedsrepræsentanten« til: »Arbejdsmiljørepræsentanten«.

7. I *§ 40 e, stk. 1,* ændres »et sikkerhedsudvalg« til: »en arbejdsmiljøorganisation«.

8. I *§ 40 e, stk. 2, 1. pkt., stk. 3* og *4,* ændres »Sikkerhedsudvalgets« til: »Arbejdsmiljøorganisationen«.

9. I *§ 40 e, stk. 2, 1. pkt., § 40 f, 1. pkt.,* og *§ 40 g, stk. 2,* ændres »sikkerhedsrepræsentanter« til: »arbejdsmiljørepræsentanter«.

10. I *§ 40 e, stk. 2, 2. pkt.,* ændres »Det enkelte sikkerhedsudvalg« til: »Den enkelte arbejdsmiljøorganisation«.

11. I *§ 40 f, 1. pkt.,* ændres »sikkerhedsudvalget« til: »arbejdsmiljøorganisationen«.

12. I *§ 40 g, stk. 2,* ændres »sikkerhedsudvalg« til: »arbejdsmiljøorganisationer«, og »udvalgets« ændres til: »arbejdsmiljøorganisationens«.

13. Efter kapitel 9 indsættes:

»Kapitel 9 a

Regulering af mindre droner

Definition

§ 126 b. Ved en drone forstås et ubemandet luftfartøj.

Stk. 2. Ved en mindre drone forstås et ubemandet luftfartøj, som ligger inden for den øvre vægtgrænse, som er fastsat i medfør af stk. 3.

Stk. 3. Transport- og bygningsministeren fastsætter nærmere bestemmelser om en øvre vægtgrænse for, hvad der forstås ved en mindre drone.

Stk. 4. Transport- og bygningsministeren kan fastsætte bestemmelser om, at mindre droner under en nærmere fastsat minimumsvægtgrænse helt eller delvis undtages fra reglerne i denne lov.

Operative flyveregler

§ 126 c. Flyvning med mindre droner skal udføres på en sådan måde, at andres liv og ejendom ikke udsættes for fare eller anden unødig ulempe.

Stk. 2. Flyvning med mindre droner må alene ske uden for flyvesikkerhedsmæssigt kritiske områder, sikringsmæssigt kritiske områder og særligt følsomme naturområder, medmindre andet følger af bestemmelser fastsat i medfør af stk. 4 og 5 og § 126 i.

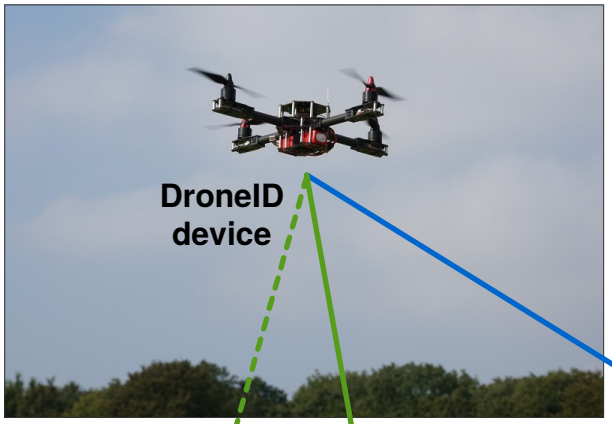
Stk. 3. Transport- og bygningsministeren fastsætter nærmere bestemmelser om operative flyveregler.

Stk. 4. Transport- og bygningsministeren fastsætter nærmere bestemmelser om flyvning over flyvesikkerhedsmæssigt kritiske områder og særligt følsomme naturområder med mindre droner, jf. stk. 2.

AX018944

Transport- og Bygningsmin., j.nr. 2015-7537

DroneID architecture

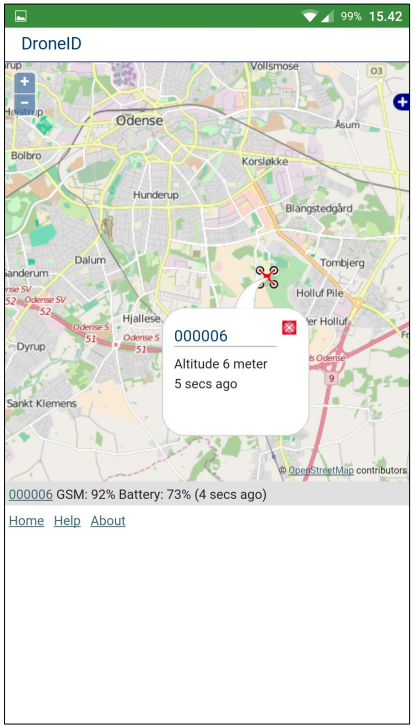


GSM signal

Radio beacon signal

Relayed signal

GSM netvork

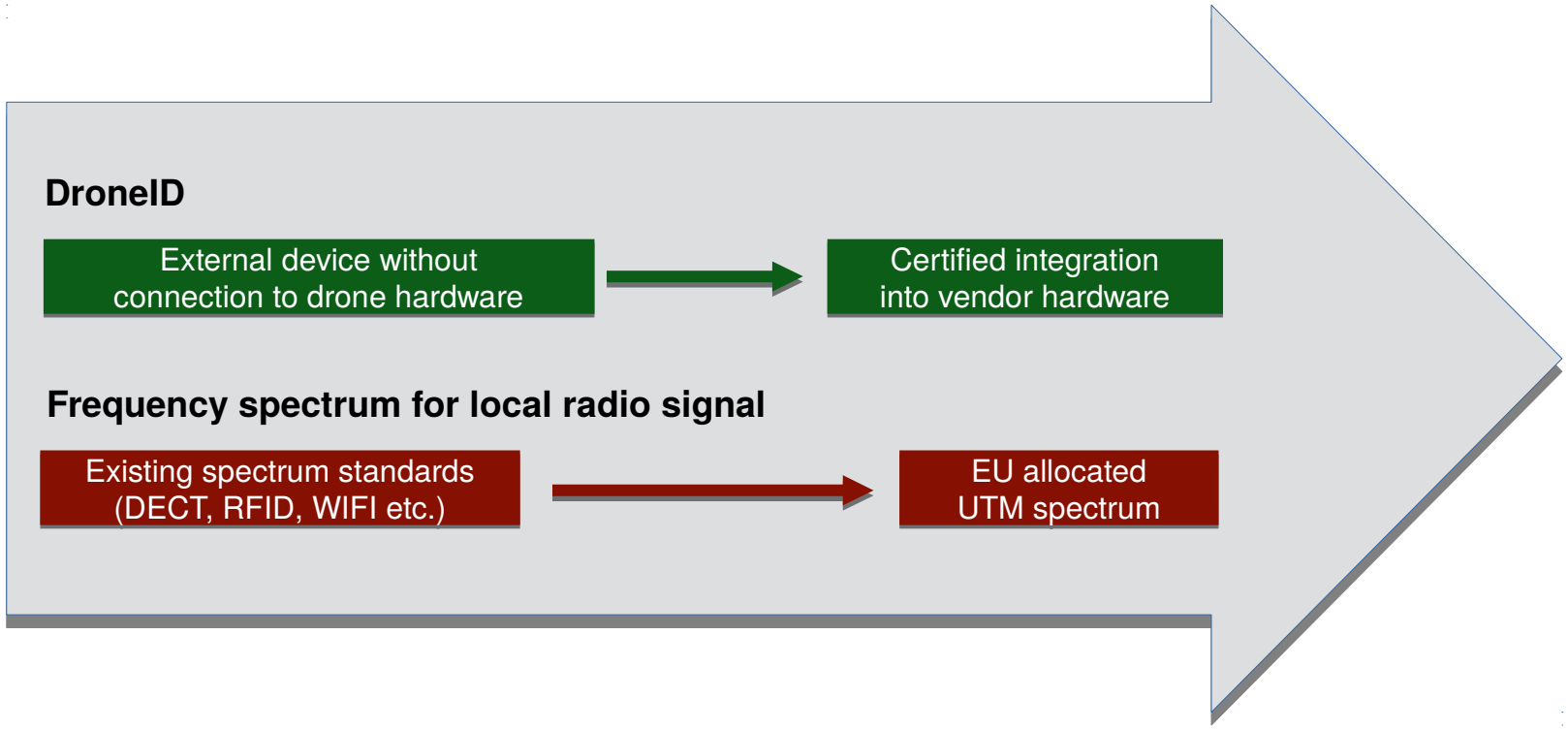


Authorities &
Public access

Flight plan

UAS Traffic
Management (UTM)

Implementation road map



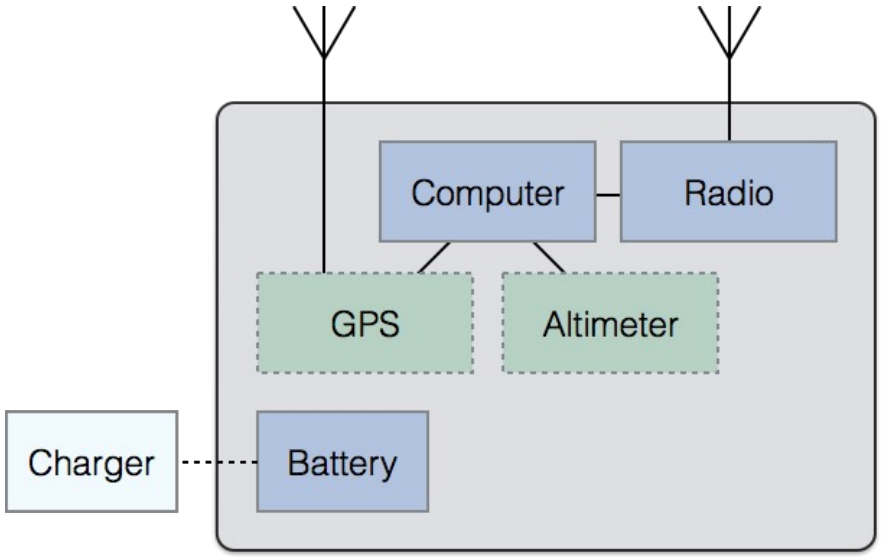
External DroneID device

Transmitted data (encrypted)

- Unique ID
- Position, elevation
- Optional data (based on sensors):
  - Velocity, heading
  - Flight time

Hardware

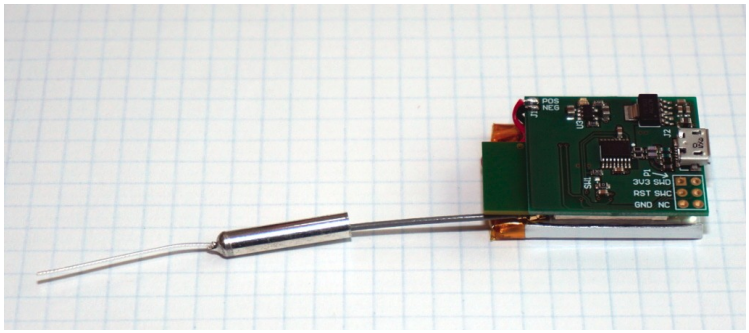
- Self contained, no interface to drone
- Very small form factor
- Light weight
- Low power operation
- GNSS (GPS) and altimeter



Hardware components

Prototypes tested in 2015

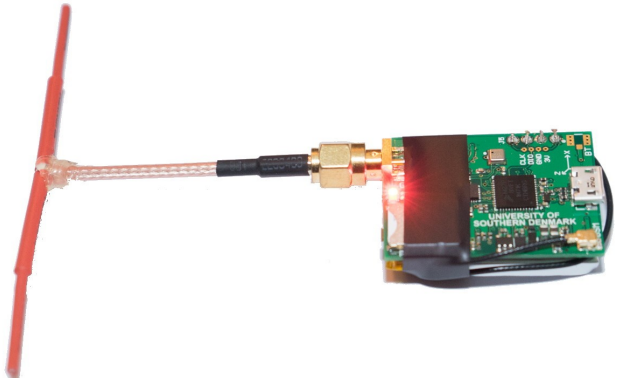
Radio beacon



- Wifi radio
- External 2.4 GHz antenna
- Weight approx. 10g plus casing
- No connections to the drone
- Micro USB charging

- Expected working range 500 - 1000m
- May require receiver hardware, antenna etc.
- No ground based infrastructure.
+ Lower size, weight, power.
+ Lower price

GSM



- GPRS modem
- GNSS with external dipole antenna*
- Weight approx. 20g plus casing
- No connections to the drone
- Micro USB charging
- Battery lasts approx. 3 hours of flight time.

- Coverage limited by network (potential MVNO roaming).
+ No receiver hardware needed.
+ Infrastructure already established
- Higher size, weight, power.
- Higher price.
- Requires SIM card and subscription.

**The external dipole antenna allows installation of the DroneID on the side or beneath the drone body.*

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UTM record example

Flight

- Activity ID — unique
- Status — planned/ongoing/completed/cancelled
- Start — date and time
- End — date and time
- Geofence — polygon describing boundary of operation
- Type — commercial/recreational
- Purpose — specified e.g. training/inspection/transport etc.

Drone

- Drone ID — issued by authority
- Type — autofill if ID is available
- Payload — e.g. camera/sensor

Pilot

- Name
- Address
- Phone
- Email
- Company

Authorization

- Status — not required/pending/approved/denied
- Authorities — autofill based on location and drone ID

UAS Traffic Management (UTM)

Activity records will automatically be validated (based on drone ID and geofencing) against static and dynamic restricted airspace and submitted for approval by relevant authority.

Experiment conducted in 2015

- 10 drone operators installed a DroneID device (GSM) for one month starting November 2015.
- Drone flights were tracked, the drone pilots also logged the flight activity on a web based logbook for reference.
- Workshops held for drone operators, industrial partners, the police and other stakeholders focusing on demonstrations, user experience and feedback etc.

Partners

- Danish Transport and Construction Agency
- University of Southern Denmark
- *UAS Denmark*

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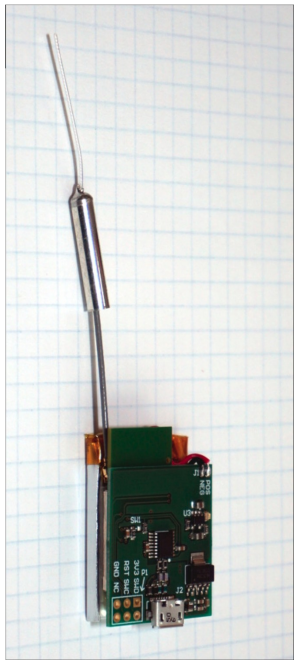
Industrial partners

DRONESOFT

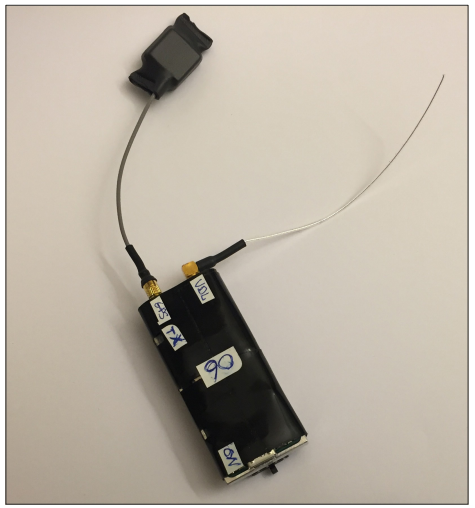
UTM service supporting mobile App interface

RESEIWE
software for wireless reliability



Reliable wireless data link showcase

SA
Scandinavian Avionics A/S



DroneID radio beacon showcase

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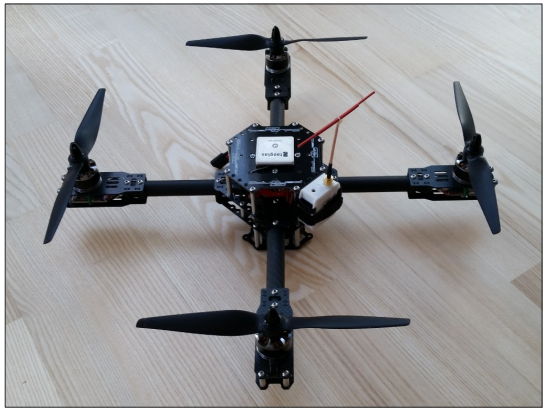
DroneID installation guidelines

- Installation on the side or beneath the drone body to ensure that the drone GNSS antenna is not obstructed.
- Installation far away from other antennas with the DroneID logo (and hence GSM antenna) facing away from the drone body.
- DroneID GNSS antenna must have a clear view of the sky without obstructing the drone GNSS antenna or touching propellers. Antenna and cable should not be directly parallel to or near other antennas.
- Mount using electrical tape, velcro, cable binders etc.

Installation examples

MikroKopter



Viacopter EduQuad

senseFly eBee

DJI Inspire 1

DJI Phantom 2

DJI S900

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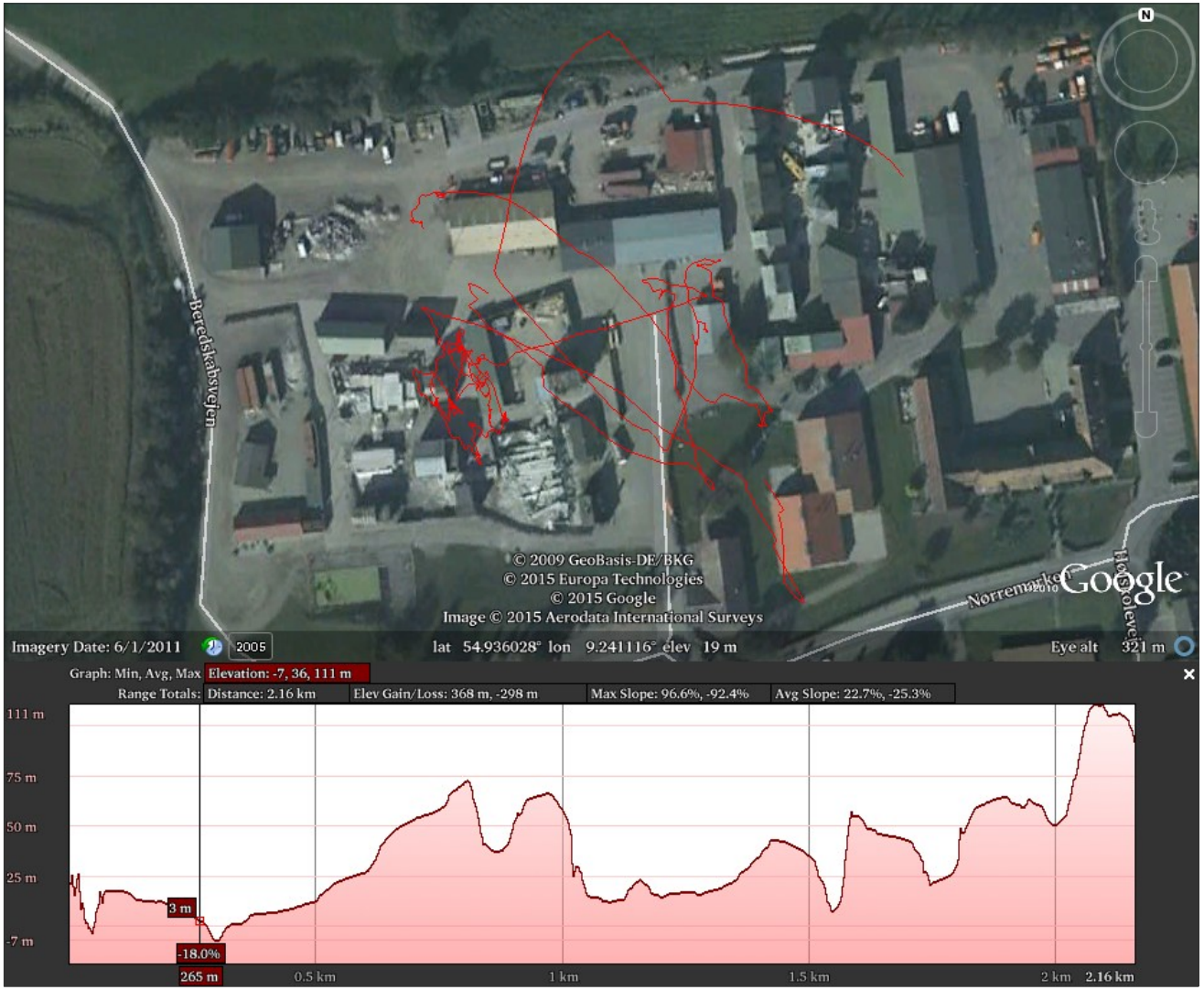
Crop surveying example

Aarhus University, ebee drone, windy conditions

Manual inspection example

Danish Emergency Management Agency, DJI Phantom 2



GPS track comparison

DroneID prototype vs. AutoQuad flight controller.

Experiment results 2015

Cold, windy and rainy weather conditions gave less test flights than expected. During the 30 days 19 operator flight days were recorded, each with typically 2-4 takeoffs. Only few flights were in urban environments. Most important issues were:

- 1 instance of drone entering safe-mode, most likely due to placement of GNSS antenna with respect to drone RX antenna.
- 2 instances of entire flight days not recorded due to poor GSM coverage and/or software problems.
- Few instances of tracking lost due to low battery on the DroneID. The problem is a use pattern of keeping the DroneID active while on the ground. Remaining battery time must be clearly indicated, ideally through an app as well.
- User interface was too complicated and buttons were too difficult to reach. The pilot already has many things on his mind while planning and performing flights. The pilot forgets to turn off after use (in a few instances causing recordings of the pilot driving home).
- GNSS antenna solution is less expedient during installation but it seems to work well.
- Current housing too big for the ebee drone.

Conclusion: To the extent tested in this limited experiment the DroneID (GSM) solution seems feasible. Errors and deficiencies discovered so far can expectedly be fixed in software or hardware.

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Workshop notes 2015

Police

- Inquiries from citizens concerning drones nearby private property, gardens, beaches etc. both live and historical.
- Observe and identify unauthorized drones near an ongoing police action.
- The solution should be accessible from operational centers without requiring infrastructure or officers near the drone.
- The solution should be usable by officers on foot and thus not require fixed installations in police vehicles, on buildings etc.

Air Service Navigation Provider (ANSP)

- Observe and identify drones inside and near areas controlled by the ANSP (control & information zones around airports, military, dangerous, restricted and prohibited areas).
- Ability to contact the drone pilot during flight.
- Possible use of geofencing for restricting the drone ability to enter the controlled areas.

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Workshop notes 2015 (continued)

Emergency response

- Seamless live monitoring of emergency management drones as well as unauthorized drones near an ongoing incident.
- Live and historical documentation of area coverage during searches.
- Support a division of an operation into sectors when performing large scale searches such as sea accidents.

General

- On-site monitoring of a drone beacon signal combined with a relay of updates to UTM through the pilot's smartphone raises concerns regarding reliability.
- Is it possible to use SINE www.sikkerhedsnet.dk as carrier rather than GPRS?
- Possibly synergy by combining DroneID tracking information with ADS-B data such as presented at http://www.flightradar24.com/55.5,10.48/7
- Possible synergy by issuing similar ID's to soaring planes, para gliders, hang gliders etc.

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Further work 2016

- Technical experiments assessing challenges observed during the 2015 experiment such as GPRS connection problems, GNSS antenna, user interface and battery lifetime etc.
- Developing a new version of the DroneID device.
- Extended experiment deploying both old and new versions of the DroneID device to active operators within one major city.
- Monitoring and when relevant collaborating with interested companies providing products or services related to DroneID.

Not included but relevant:

- *Investigate the legal consequences of deploying DroneID devices regarding vendor vs. state liability in the event of a drone accident possibly caused by a Drone ID device, insurance possibility etc.*
- *Investigate the possibilities for using/establishing a Mobile Virtual Network Operator (MVNO) roaming across multiple physical networks.*
- *Investigate possibilities and challenges of letting vendors implement the DroneID device functionality in the drone hardware.*

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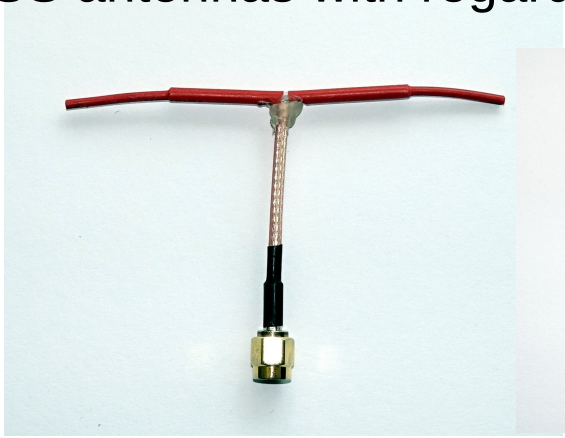
GNSS antenna experiments

Test of various GNSS antennas with regards to Signal to Noise Ratio (SNR).

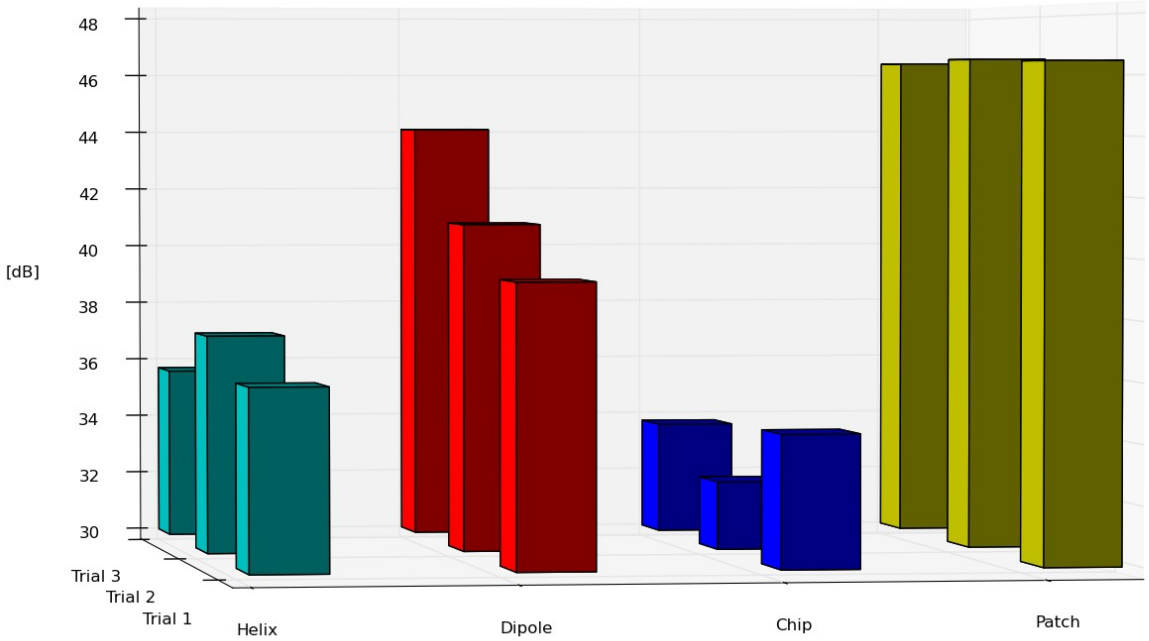
Helix



Dipole

Chip

Patch



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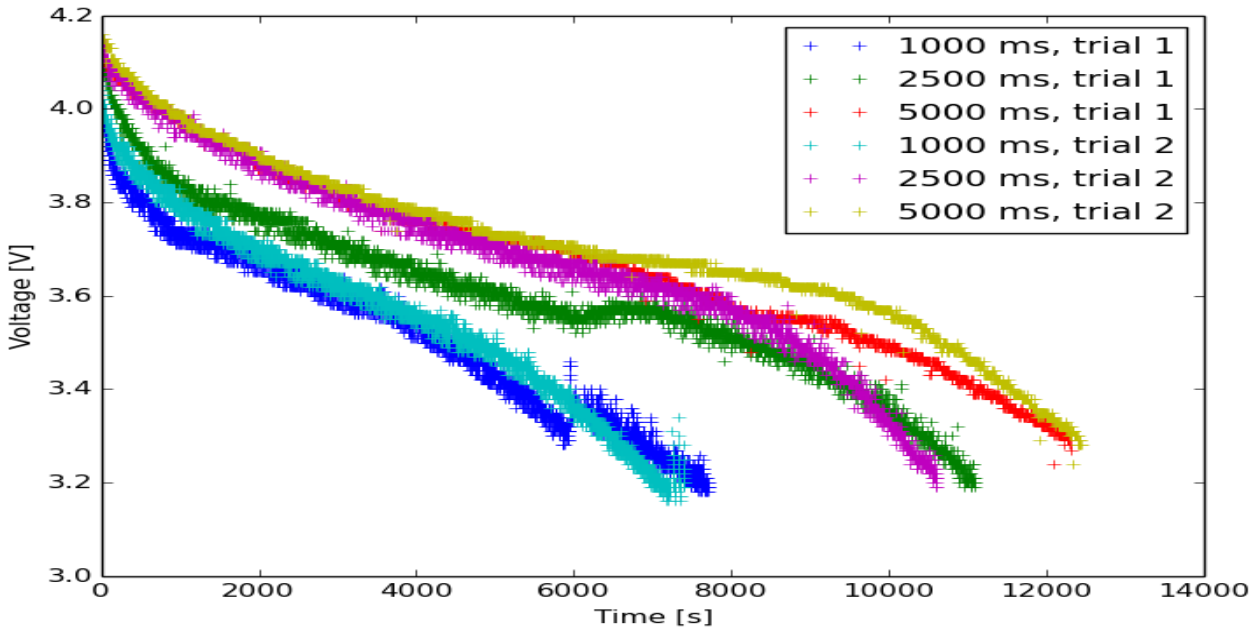
Battery lifetime experiments

Battery life > 2 hours when updating each second.

Battery life > 3 hours when updating each 2.5 seconds.

Battery life > 3.5 hours when updating each 5 seconds.



The data are based on several conditions held fixed but not fully controllable within the experiment such as battery cell capacity, distance to GPRS cell tower, DroneID software version etc. The results should therefore be used for a qualitative evaluation of the relative differences.

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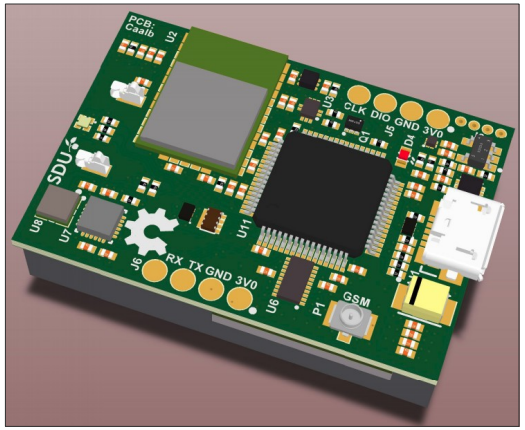
DroneID device v2

Hardware updates

- Possible internal GNSS antenna.
- One-button, one-LED user interface.
- Longer battery lifetime.
- Smaller and lighter.
- Increased weather resistance.
- New CPU
- New GSM/GNSS modules not embargoed by ITAR.



Software updates

- Simpler user interface.
- GSM & GNSS signal strength reports which may assist the pilot in selecting the optimal positioning of the device.
- Inflight detection using inertial sensors.
- More accurate altitude reporting using barometer measurements.
- Binary protocol with checksum.
- Possible encryption.
- Varying update rate based on done movements and/or access requests.

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Field experiment 2016

During Summer 2016 deploy DroneID devices to select operators with dispensation in a major city (Copenhagen or Odense) while at the same time provide the police with access to live and historical flight information. There will be public access to limited live flight information.

Expected results:

- Feedback from operators/pilots.
- Feedback from the police.
- GSM coverage maps to document feasibility.
- Test of the UTM service and DroneID device.
- Showcase demonstrating practical implications of deploying DroneID.

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Thank you for listening!

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